TinyNode™ 584 / Standard Extension Board

User's Manual

Rev 1.1, November 2005

Document Control

Revision	Author	Date	Note
1.0	RM	23.03.2005	Initial Release
1.1	MM, PM	14.11.2005	TinyNode Development Environment Installation Generic install instructions updated

Table of Contents

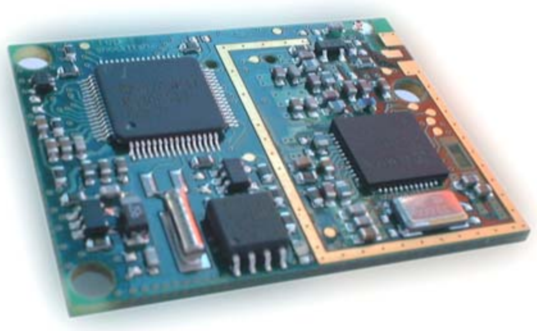
Introduction

The goal of this manual is to describe the hardware features of the TinyNode module and the Standard Extension Board.

TinyNode 584

Product Summary

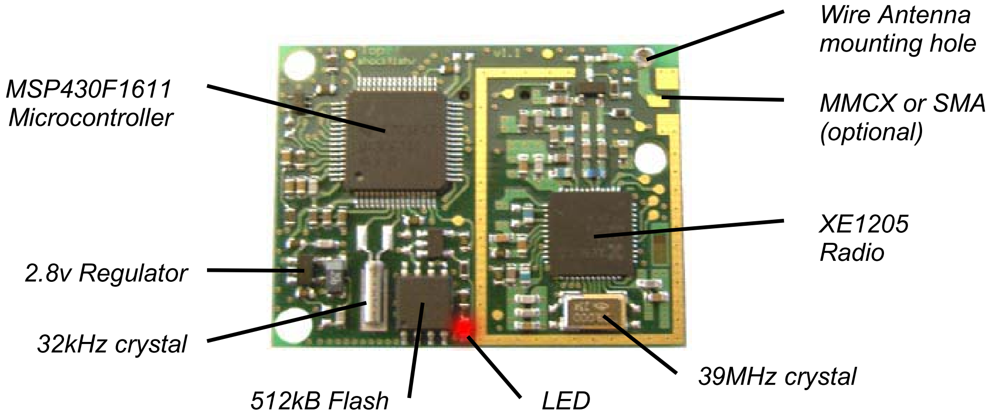
The TinyNode 584 is an ultra-low power OEM module that provides a simple and reliable way to add wireless communication to sensors, actuators, and controllers. TinyNode 584 is optimized to run TinyOS and packaged as a complete wireless subsystem with configurable interfaces.

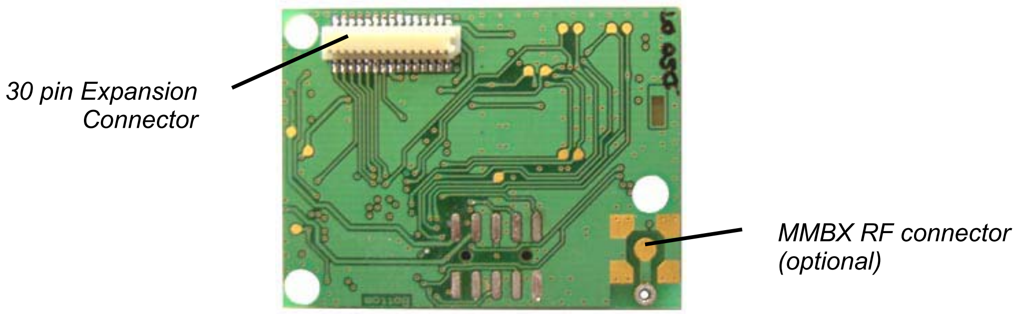


Key Features

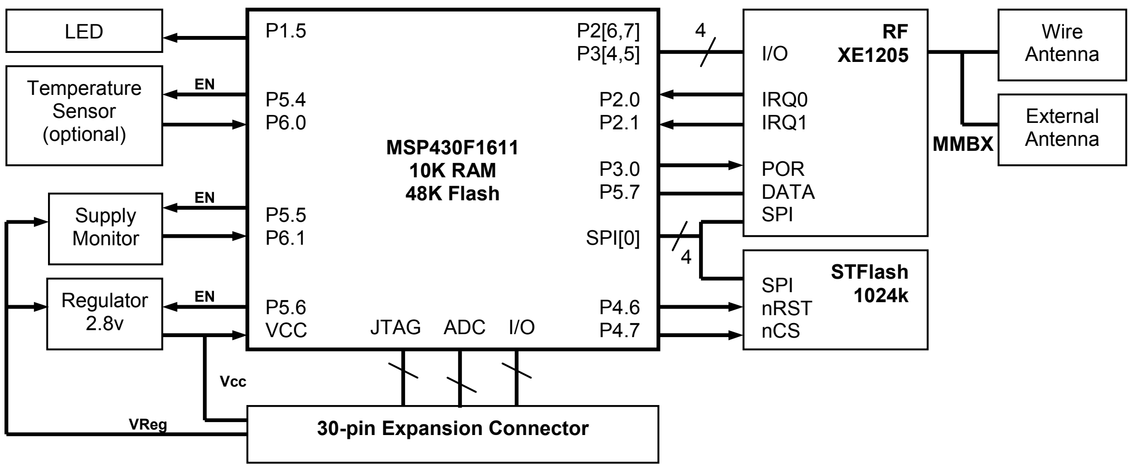
- Ultra Low Power 3 V design
- Texas Instruments MSP430 microcontroller
- Fast wakeup from sleep (<6µs)
- 868 MHz Xemics XE1205 ultra-low power multi channel wireless transceiver
- Software adjustable Bandwidth
- High sensitivity (down to -121 dBm)
- Transmitter output power up to +12 dBm
- On-board 1/4 wave wire antenna, footprint for external antennas
- Analog, digital and serial interfaces
- Out-of-the-box TinyOS support for mesh networking and communication implementation
- Small: 30x40 mm

Module Overview





Functional Block Diagram



Typical Operating Conditions

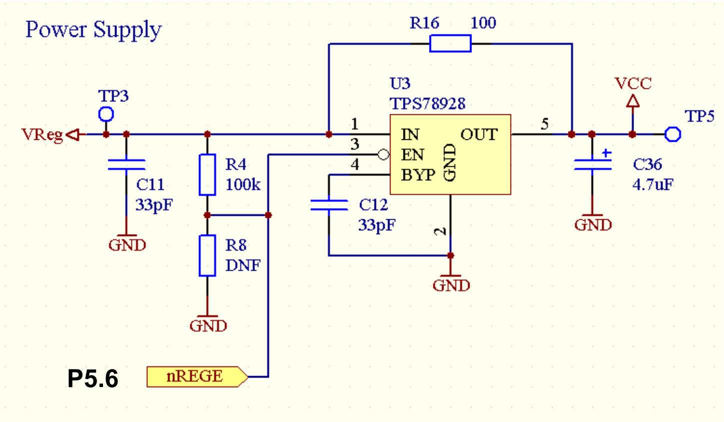
	Min	Typ[1]	Max[2]	UNIT
Supply voltage:				
Supply voltage (VCC or VReg)	2.4		3.6	V
Supply voltage during flash memory programming	2.7		3.6	V
Current Consumptions:				
µC sleep with Timer off (LPM4)		4.1	18.9	µA
µC sleep with Timer on (LPM3)		6.5	21.9	µA
µC active		2.1	2.6	mA
µC active, Radio RX		16	19	mA
µC active, Radio TX at +0dBm (1mW)		25	32	mA
µC active, Radio TX at +5dBm (3.2mW)		35	42	mA
µC active, Radio TX at +10dBm (10mW)		46	53	mA
µC active, Radio TX at +12dBm (16mW)		62	69	mA
µC active, Flash Read		6	12	mA
µC active, Flash Write		17	38	mA
Temperature Limits:				
Storage Temperature	-40		80	°C
Operating free air temperature	-40		80	°C

Power

For battery operation, a TinyNode can be powered directly on VCC using two AA alkaline cells or one lithium cell. The operating voltage range is from 2.4v to 3.6v DC.

When programming the microcontroller or the external Flash, the voltage has to be at least 2.7v. Below 2.25v, an external reset circuit holds the microcontroller's reset pin low to avoid unpredictable behavior at low voltages.

For a stable 2.8v supply, an onboard linear voltage regulator (TPS78928) can be used. In that case, the board can be powered over VReg ranging from 2.4 to 3.6v DC. Below 2.8v, the VCC voltage will follow the VReg voltage. For saving power during Stand-By mode, the regulator needs to be shut down with the nREGE pin connected to P5.6 of the microcontroller. The microcontroller will still be powered over R16, but it needs to re-enable the regulator after wake-up and before activating any periphery.



The 30-pin Expansion connector described in chapter Expansion Connector provides both VReg and VCC to the module.

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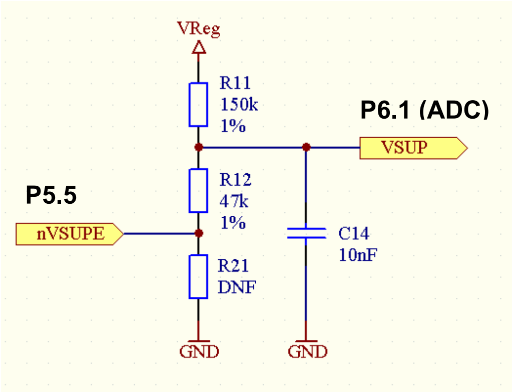
[1] Typical values at VCC = 3V, T at 25°C

[2] Maximum values at VCC = 3.6V, T from –40°C to 85°C

Supply Monitor

The supply voltage can be monitored using the onboard resistive bridge. The nVSUPE should be configured as an entry on the microcontroller to avoid current flow. To activate the bridge, it needs to be set as a low-level output pin. The voltage level at VSUP can then be converted using the following formula: VSUP = VReg*0.239.



Microcontroller (MSP430F1611)

General

The MSP430 family architecture features five low power modes and is optimized to achieve extended battery life in portable measurement applications. The MSP430F1611 ultra low power microcontroller has 10kB of RAM, 48kB of flash, and 128B of memory. It features a powerful 16-bit RISC CPU with 16-bit registers.

The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 6μs and may operate up to 8MHz. Typically, the DCO will turn on from sleep mode in 300ns at room temperature. The MSP430F1611 has two built-in 16-bit timers, a fast 12-bit A/D converter, dual 12-bit D/A converter, one or two universal serial synchronous/asynchronous communication interfaces (USART), I2C, DMA, and 48 I/O pins.

Internal Temperature and Voltage Monitoring

The ADC internal ports may be used to read the internal thermistor on ADC port 10 or monitor the supply voltage (VCC) on ADC port 11. The temperature sensor consists of an uncalibrated diode that can have a large offset error (up to 20°C). A single point calibration is recommended for most applications.

Typical Operating Conditions:

	Min	Typ[3]	Max[4]	UNIT
Supply voltage				
Supply voltage	1.8		3.6	V
Supply voltage during flash memory programming	2.7		3.6	V
Current Consumptions				
Sleep current, Timer off (LPM4)		0.2	5.0	μA
Sleep current, Timer 32.768kHz (LPM3)		2.6	8.0	μA
Active current, 1MHz		500	600	μA
Active current, 4MHz		2.1	2.6	mA
Low Frequency Crystal				
Center Frequency		32.768		KHz
Calibration Tolerance at 25°C		20		ppm
Temperature Coefficient (-40..85°C)		-0.034		ppm/°C
Temperature Limits				
Storage Temperature	-40		80	°C
Operating free air temperature	-40		80	°C

For more detailed information, please refer to the datasheet that is available at http://www.ti.com/msp430

[3] Typical values at VCC = 3V, T at 25°C
[4] Maximum values at VCC = 3.6V, T from –40°C to 85°C

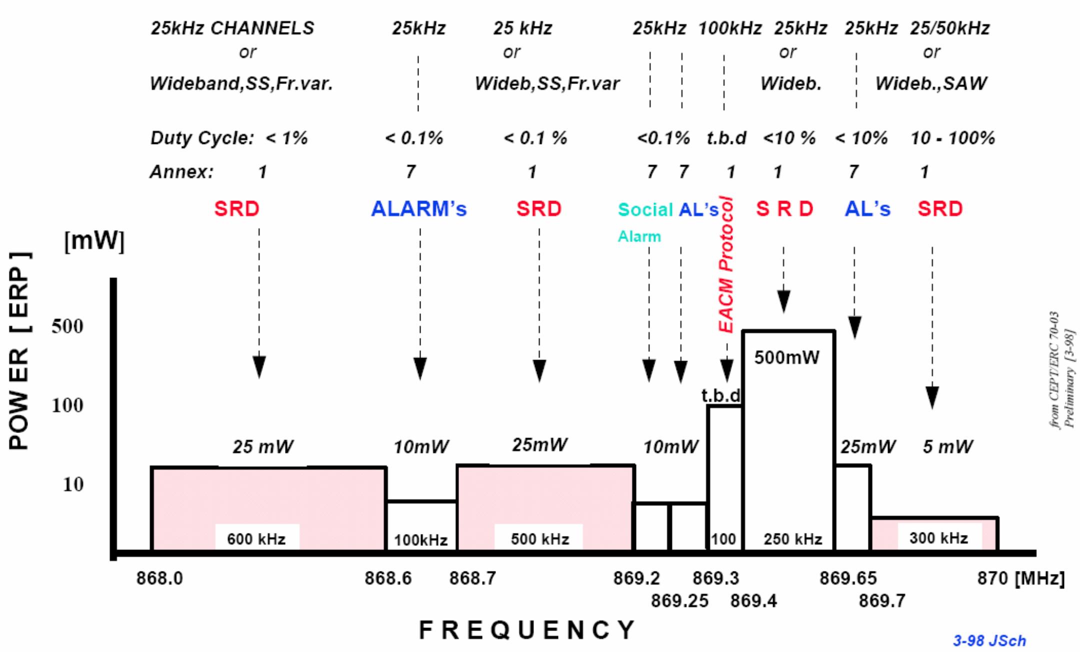
RF (XE1205)

General:
The XE1205 from XEMICS is an integrated transceiver that can operate in the 433, 868 and 915MHz license-free ISM (Industry Scientific and Medical) frequency bands. The current design of TinyNode 584 supports European 868MHz operation.

All major RF communication parameters are programmable and most of them can be dynamically set. The XE1205 offers the unique advantage of narrow-band and wide-band communication with the same hardware configuration. The XE1205 is optimized for low power consumption while offering high RF output power.

SRD Band Plan 868…870 MHz
For operation in Europe, the 868MHz band offers several advantages over the 433MHz band:

- Regulated duty cycle ideal for low power sensor applications
- Power levels up to 500mW
- Wide-band and channelized narrow-band operations possible
- Less “crowded” (a lot of toys and keyless entry system work at 433MHz)



Downloads:
ERC/DEC(01)04 decision for SRD bands**:**
http://www.ero.dk/documentation/docs/docfiles.asp?docid=1463
implementation status for SRD bands:
http://www.ero.dk/documentation/docs/implement.asp?docid=1463

For one channel operation, the standard center frequency setting for a TinyNode is 868.300MHz. Data rates up to 153kbit/s are possible within the 868.000 – 868.600MHz band. Channel and Bandwidth settings can be configured by software.

It is the responsibility of the programmer to respect duty cycle and power regulations for his application.

Typical operating conditions

	Min	Typ[5]	Max[6]	UNIT
Supply voltage:				
Supply voltage	2.4		3.6	V
Current Consumptions				
Sleep mode		0.2	1.0	µA
Standby mode (39MHz quartz oscillator enabled)		0.85	1.1	mA
Receive mode		14	16.5	mA
Transmit mode +5dBm		33	40	mA
Transmit mode +15dBm		62	75	mA
RF performance				
RF Sensitivity, A-mode, 1.2kbit/s		-121	-118	dBm
RF Sensitivity, A-mode, 4.8kbit/s		-116	-113	dBm
RF Sensitivity, A-mode, 19kbit/s		-110	-107	dBm
RF Sensitivity, A-mode, 76.2kbit/s		-104	-101	dBm
RF Sensitivity, A-mode, 152.3kbit/s		-101	-98	dBm
Frequency deviation, programmable	1		255	kHz
Base band filter bandwidth (SSB), programmable[7]		10		kHz
		20		kHz
		40		kHz
		200		kHz
RF output power, programmable				
RFOP1	-3	0		dBm
RFOP2	+2	+5		dBm
RFOP3	+7	+10		dBm
RFOP4	+12	+15[8]		dBm
Synthesizer frequency range (868MHz band)	863		870	MHz
Timings				
TS_OS: Quartz oscillator wake-up time		1	2	ms
TS_SRE: RX wake-up time (Quartz oscillator enabled)		700	850	µs
TS_STR: TX wake-up time (Quartz oscillator enabled)		250	350	µs
TS_TFSW: TX recovery time when switching channels		150	250	µs
TS_RSSI: RSSI wake-up (Receiver enabled)		2/BR		ms
RSSI				
VTHR, Equivalent input thresholds (A-mode)				
low range: VHTR1		-110		dBm
VHTR2		-105		dBm
VHTR3		-100		dBm
high range: VHTR1		-95		dBm
VHTR2		-90		dBm
VHTR3		-85		dBm
39MHz Crystal				
Center Frequency, Fundamental mode		39		MHz
Calibration Tolerance at 25°C		15		ppm
Stability over temperature range (-40°C to 85°C)		20		ppm
Temperature Limits				
Storage Temperature	-40		80	°C
Operating free air temperature	-40		80	°C

5 Typical values at VCC = 3V, T at 25°C
6 Maximum values at VCC = 3.6V, T from –40°C to 85°C
7 Additional bandwidth settings possible, please consult datasheet for more detail
8 At +15dBm, typical output power of the board is +12dBm (matching optimal for 0..+10dBm)

For more detailed information, please refer to the datasheet that is available at http://www.xemics.com

Changing the data rate:
The XE1205 can be programmed for wide band (higher data rate, lower bandwidth) or narrow band (lower data rate, higher range) communication.

Please consider the following when changing the data rate:
1) The TinyNode is a very flexible module because of the configurable parameters it supports. However, modules that are not configured in the same way will not be able to communicate reliably, causing poor performance or failure of the wireless link. **All modules in a network must have the same mode configuration to ensure interoperability.**

2) **The transmitters frequency deviation and the receivers filter bandwidth have to be set according to the data rate**. As a rule of thumb:

FREQ_DEV [kHz] > Data Rate [kbit/s]
*RX_BW [kHz] > FREQ_DEV [kHz] * 2*

3) The 39 MHz crystal frequency tolerance of +/- 20ppm directly translates into a RF center frequency tolerance of 20ppm or +/- 18kHz at 868 MHz. This means that the maximum misalignment at room temperature between a sending and a receiving node can be 2*18kHz = 36 kHz. If the nodes are at different temperatures, you have to add the temperature drifts as well. **If the misalignment of the sender's and the receiver's frequency is bigger than the frequency deviation of the sender, a link will not be possible**. In that case, the FEI function (frequency error indication) of the XE1205 can be used in order to compensate the frequency offset. Please refer to the datasheet for a detailed description of this feature.

Link budgets and Range:
A link budget is the best figure for comparing range performances. To calculate the link budget for a wireless link, simply add the transmit power and the antenna gains, then subtract the receiver sensitivity:

LinkBudget[dB] = TXpower[dBm] + TXAntGain[dBi] + RXAntGain[dBi] – RXSensitivity[dBm]

For example, the typical link budget for a pair of TinyNodes at +10dBm, 76kbit/s with ¼ wave whip antennas will be:

LinkBudget[dB] = 10dBm + 0dBi + 0dBi – (-104dBm) = ***114 dB***

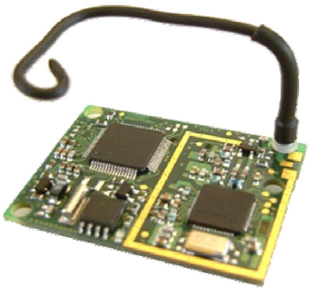
A link budget of 114dB easily yields a range of 200m or more outdoors and 40m or more indoors. Following table gives an overview with typical data rate settings:

DataRate	**152.3**	**76.2**	**9.6**	**1.2**	**kbit/s**
Receiver Bandwidth	400	200	20	7	**kHz**
Receiver Sensitivity	-101	-104	-113	-121	**dBm**
Transmit Power	10	10	10	10	**dBm**
Transmit Frequency deviation	100	80	10	2	**kHz**
Link Budget with ¼ wave whip antenna	110	114	123	131	**dB**
Typical Range, outdoor, Line of Sight	150	200	600	1800	**m**
Typical Range, indoor[9]	30	40	80	200	**m**

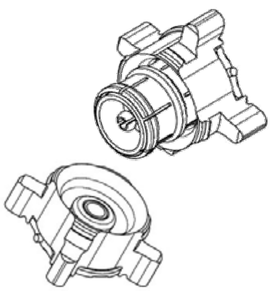
[9] Indoor range will depend largely on the structure of the building and the number of walls the signal needs to pass through. Figures above are for typical office environments.

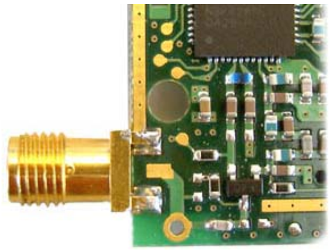
Antenna Options
Care should be taken to the antenna configuration in order to get the best range performance. Any degradation in the antenna gain will directly diminish the link budget and the range.

¼ wave wire antenna
The TinyNode module is supplied with a ¼ wave monopole wire antenna that gives good performance when the wire is kept straight or bent with enough distance from any electrical mass (see configurations below). As a rule of thumb, the antenna should not be bent any closer than 20mm to the PCB board.



MMBX or SMA antenna connectors (optional)
The back side of the TinyNode PCB allows to solder a SMT MMBX connector for connection of an external antenna or board-to-board connection of the RF signal. Another option is to mount a SMA connector at the edge of the board (see photos). Both connectors need to have 50 Ohms impedance. For hand mounting, the MMBX connector needs to be soldered with hot air.

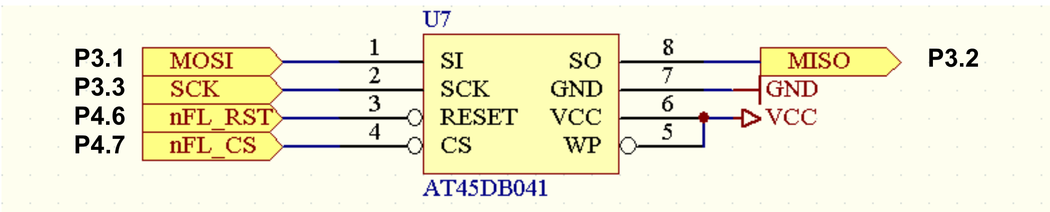




The exact part numbers and suppliers for the connectors can be found in chapter *Part Numbers and Suppliers*.

External Flash
TinyNode features a 4-Mbit serial flash (**Atmel AT45DB041**) for external data and code storage. The flash holds 512kB of data and is decomposed into 2048 pages of 264 Bytes/Page. Both page and block erase operations are supported.

The flash shares SPI communication with the XE1205 transceiver. Care must be taken when reading or writing to flash while communicating over the radio. This can be done with a software arbitration protocol for the SPI bus on the microcontroller.

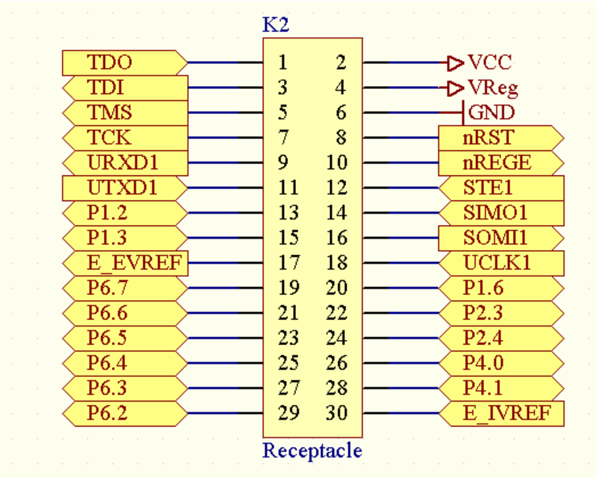


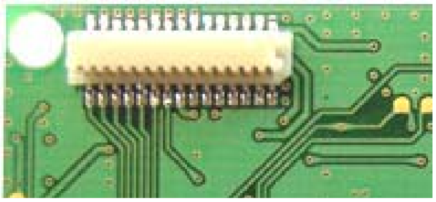
Typical operating conditions

	Min	Typ[10]	Max[11]	UNIT
Supply				
Supply voltage during flash memory programming	2.5		3.6	V
Current Consumptions				
Stand-By current		2	10	µA
Active current READ		4	10	mA
Active current PROGRAM / ERASE		15	35	mA
Timings				
Page Erase and Programming Time			20	ms
Page Programming Time			14	ms
Page Erase Time			8	ms
Block Erase Time			12	ms
Temperature Limits				
Storage Temperature	-40		80	°C
Operating free air temperature	-40		80	°C

For more detailed information, please refer to the datasheet that is available at http://www.atmel.com

Expansion Connector
The expansion connector provides a user interface for sensor boards and base stations. The connector includes interfaces for power and ground, JTAG for programming and debugging, ADC inputs and DAC outputs, UART and SPI interfaces, general-purpose digital IO and others.





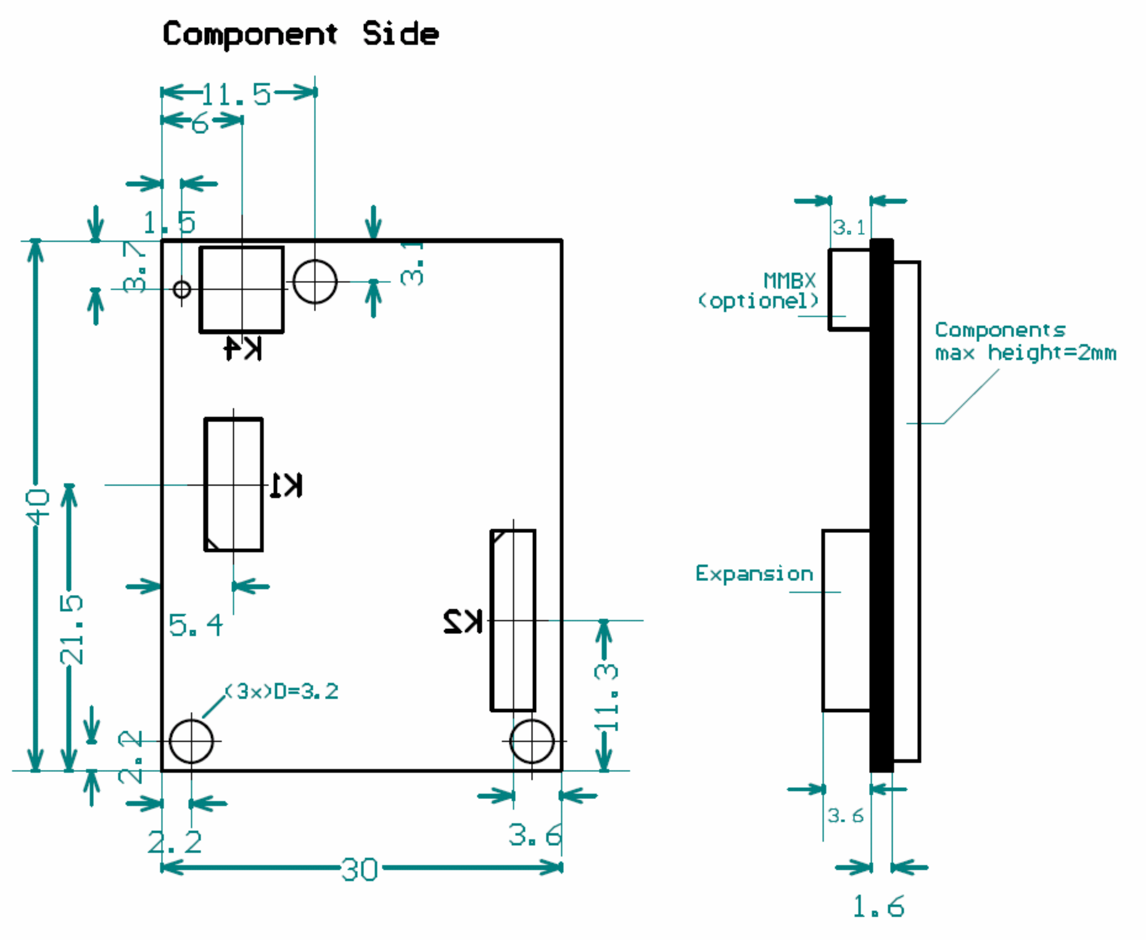
Connector mounted on TinyNode: **Molex Part No 52465-3071**

[10] Typical values at VCC = 3V, T at 25°C
[11] Maximum values at VCC = 3.6V, T from –40°C to 85°C

Pin	Name	I/O	Description	Pin	Name	I/O	Description
1	TDO	O	JTAG, TDO	2	VCC		Direct Supply (no regulator)
3	TDI	I	JTAG, TDI	4	VReg		Supply to 2.8v regulator
5	TMS	I	JTAG, TMS	6	GND		Ground
7	TCK	I	JTAG, TCK	8	nRST	I	Reset (active low)
9	URXD1	I/O	P3.7, URXD1	10	nREGE	I/O	P5.6, Regulator Enable
11	UTXD1	I/O	P3.6, UTXD1	12	STE1	I/O	P5.0, SPI STE1
13	P1.2	I/O	P1.2, TA1	14	SIMO1	I/O	P5.1, SPI SIMO1
15	P1.3	I/O	P1.3, TA2	16	SOMI1	I/O	P5.2, SPI SOMI1
17	E_EVREF	I	External Voltage Ref	18	UCLK1	I/O	P5.3, SPI UCLK1
19	P6.7	I/O	P6.7, ADC7, DAC1	20	P1.6	I/O	P1.6, TA1
21	P6.6	I/O	P6.6, ADC6, DAC0	22	P2.3	I/O	P2.3, CA0, TA1
23	P6.5	I/O	P6.5, ADC5	24	P2.4	I/O	P2.4, CA1, TA2
25	P6.4	I/O	P6.4, ADC4	26	P4.0	I/O	P4.0, TB0
27	P6.3	I/O	P6.3, ADC3	28	P4.1	I/O	P4.1, TB1
29	P6.2	I/O	P6.2, ADC2	30	E_IVREF	O	Internal Voltage Ref

The part numbers and suppliers for the mating connectors can be found in *Part Numbers and Suppliers*.

Mechanical Characteristics



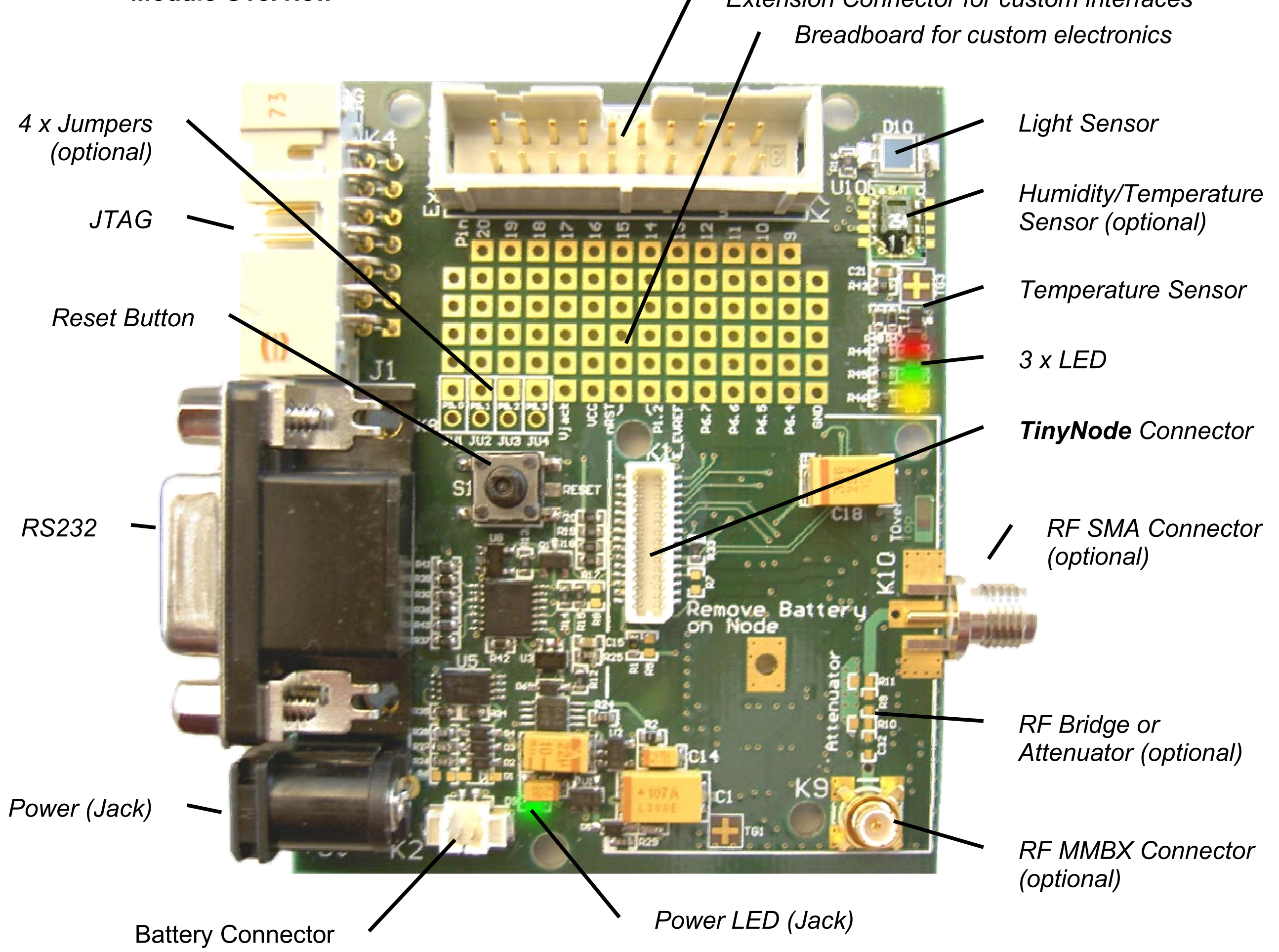
TinyNode Standard Extension Board

Product Summary:
The Standard Extension Board adds power supply; interfaces and sensors to TinyNode™ embedded wireless network nodes.

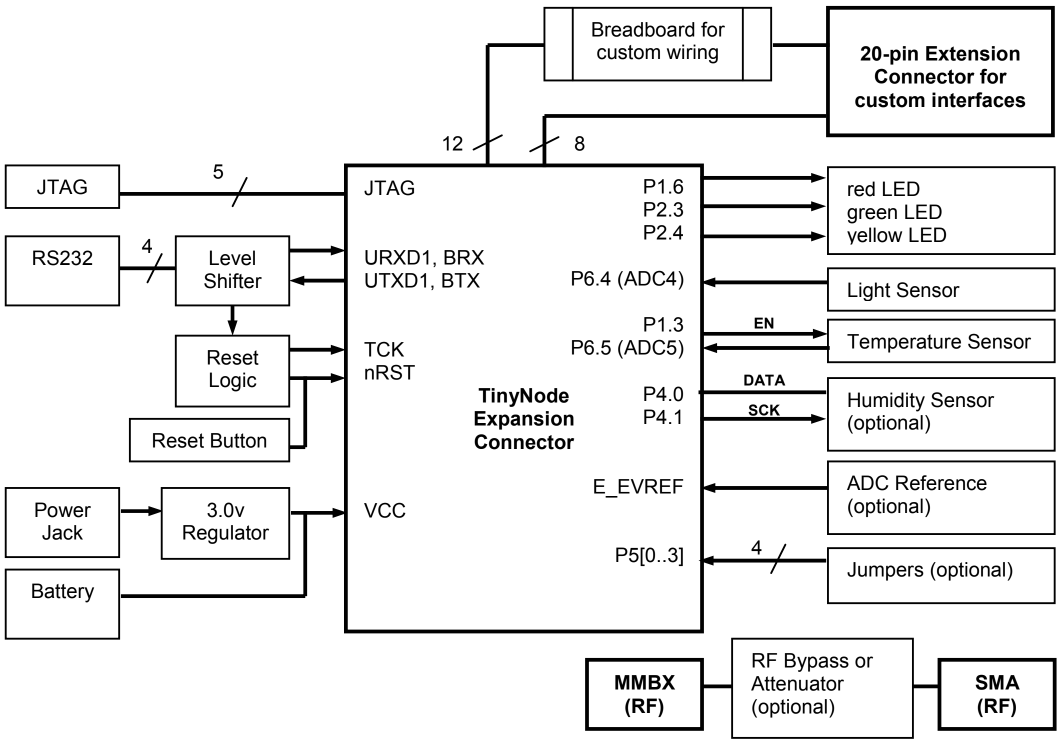
Key Features

- Mates with TinyNode™ via 30-pin expansion connector and optional MMBX board-to-board HF connector
- On Board Light and Temperature Sensor
- Footprint for Sensirion™ Humidity Sensor
- Easy integration with a wide variety of sensors and actuators
- LEDs and Jumpers
- JTAG and RS232 Connectors
- 20-pin extension connector (IDC pin-through-hole connector)
- mini breadboard for custom interfaces
- Footprint for 50 Ohm SMA connector
- Delivered with external power supply and connector for battery pack.
- Size: 74x60 mm
- Fits housing from Hammond Manufacturing

Module Overview



Functional Block Diagram



Typical Operating Conditions

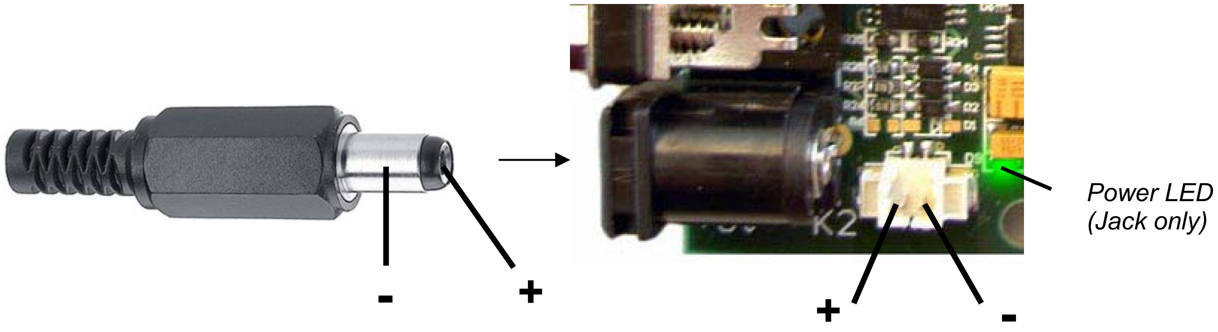
	Min	Typ	Max	UNIT
Supply voltage				
Supply voltage over Power Jack	4	5	12	V
Supply voltage over Battery Pack	see TinyNode section			
Current Consumption				
on any RS232 pin[12]			2	mA
Temperature Sensor, Active Mode (while reading)		110	210	µA
Humidity Sensor, Sleep Mode		0.3	1	µA
Humidity Sensor, Active Mode (while reading)		550		µA
External DC Reference, Active Mode		0.8	1.2	mA
Temperature Limits				
Storage Temperature	-40		80	°C
Operating free air temperature	-40		80	°C

[12] Used to supply Level Shifter and Reset Logic

Power

The Extension Board can either be powered by AC power supply via a Jack connector or a battery pack that meets the voltage and current requirements for TinyNode (see specification).

Always respect polarity and maximum voltage requirements, otherwise irreversible damage may occur!



The power LED (green) indicates that the Extension Board is powered via Jack. **To avoid continuous current consumption, the LED will NOT go on if the board is powered with a battery**.

As soon as the Jack connector is plugged, the battery connector gets disconnected mechanically, avoiding any (potentially harmful) current flow into the battery.

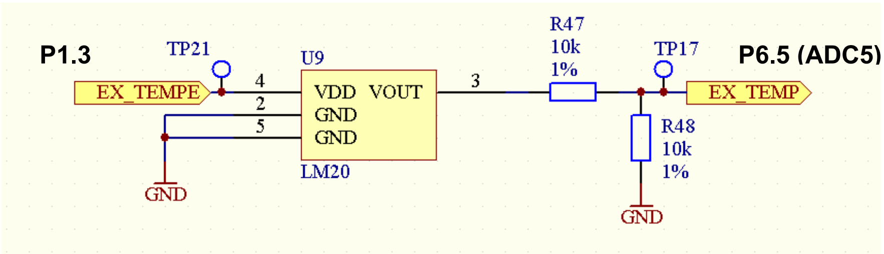
Always unplug any power supply on the TinyNode itself before connecting it to the extension board.

All RS232 interface parts are directly powered from the RS232 line and will therefore not draw any additional current from the battery.

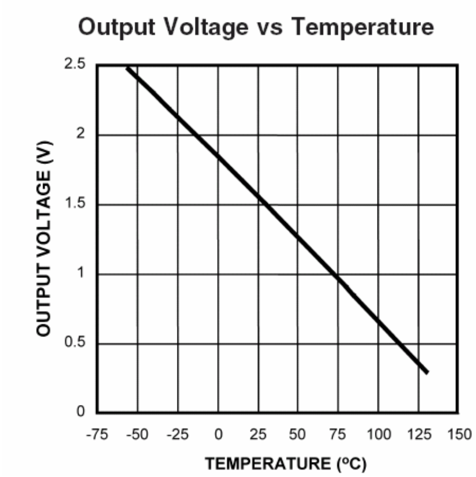
The exact part numbers and suppliers for the Jack and Battery connectors can be found in *Part Numbers and Suppliers*.

Temperature Sensor

The temperature sensor on the extension board used is the LM20 from National Semiconductor with an operating range from –55°C to 130°C. The typical accuracy is +/- 1.5°C at ambient room temperature. However, if the internal voltage reference from the MSP430F1611 is used, its tolerance needs to be taken into account and will add typically +/- 5°C of error over different supply voltages. Use a calibration point or an external voltage reference to compensate this error.



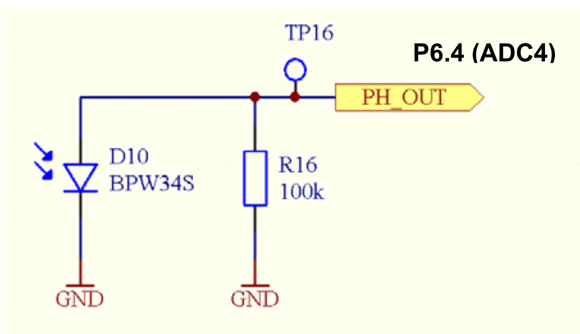
The sensor needs to be enabled by setting EX_TEMPE (P1.3) before doing a measurement. After a settle time of 500µs, the result can be read at channel 5 from the microcontrollers ADC. Figure below shows typical output voltage as a function of temperature. **To get the voltage level at the ADC input pin, this voltage needs to be divided by 2** (resistive divider).

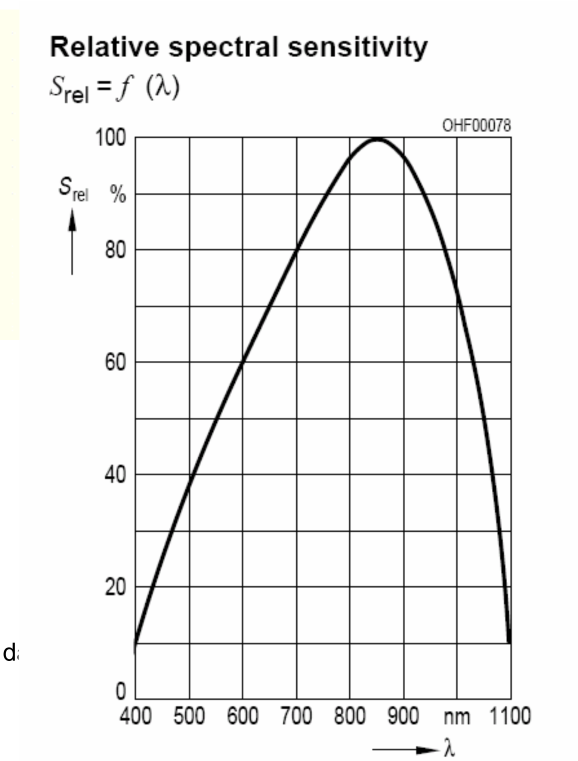


For more detailed information, please refer to the datasheet that is available at http://www.national.com/pf/LM/LM20.html

Light Sensor
The Extension Board uses a photodiode from Infineon™, Type BPW34S–P1602. The diode senses the entire visible spectrum including infrared light from 400nm to 1100nm with its peak sensitivity at 850nm. The current generated by the photodiode is converted into a voltage level via R16. The output will provide voltages from 0V (complete dark) up to around 1.2V (direct sunlight) at ADC channel 4.

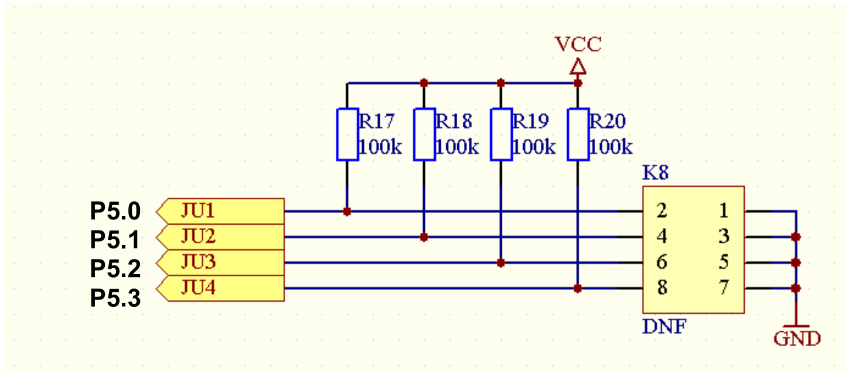
Any photodiode with similar physical dimensions may be used with TinyNode.





For more detailed information, please refer to the d

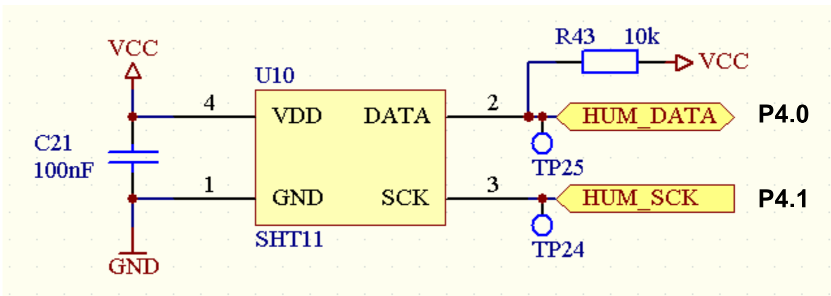
Jumpers (optional)
A 4X2 pin connector can be soldered optionally (K8) to get 4 Jumpers that can be read at P5[0..3] from the microcontroller. The pull-up resistors are already mounted on the board.



The exact part number and supplier for the Connector can be found in *Part Numbers and Suppliers*.

Humidity/Temperature Sensor (optional)
The humidity/temperature sensor SHT11 or SHT15 can be mounted on the board at the U10 component position. You will also need to mount resistor R43 (10k, 1%, 0603) and capacitor C21 (100nF, 0603).

The SHT11/SHT15 sensors have their calibration coefficient stored in the sensors onboard EEPROM. The SHT15 produces higher accuracy results than the SHT11. It provides a digital output that can be read via the HUM_DATA (connected to port P4.0) and the HUM_SCK (connected to port P4.1) pins.



1 Sensor Performance Specifications(1)

Parameter	Conditions	Min.	Typ.	Max.	Units
Humidity					
Resolution		0.5	0.03	0.03	% RH
		8	12	12	bit
Repeatability			±0.1		% RH
Accuracy(2) & Interchangeability			see figure 1		% RH
Nonlinearity	10 - 90 %RH		±3		% RH
Range		0		100	% RH
Response time	1/e (63%) slowly moving air		4		s
Hysteresis			±1		% RH
Long term stability	Typical		< 1		% RH/yr
Temperature					
Resolution		0.04	0.01	0.01	°C
		12	14	14	bit
Repeatability			±0.1		°C
Accuracy			see figure 1		°C
Range		-40		123.8	°C
Response Time			20		s

Table 1 Sensor Performance Specifications

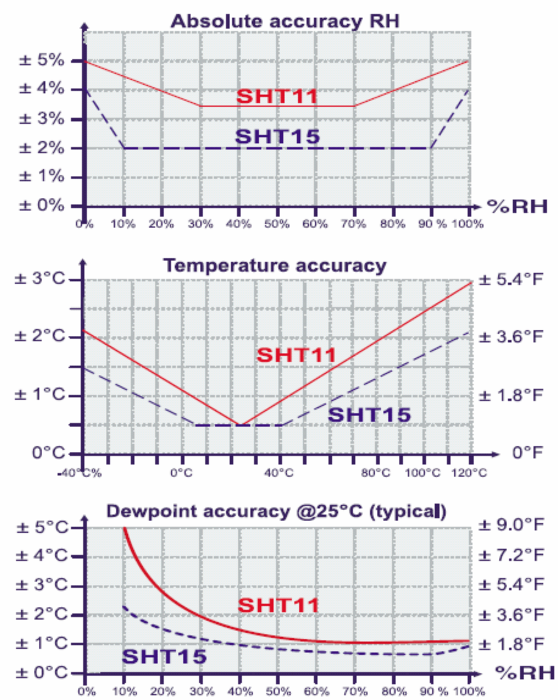


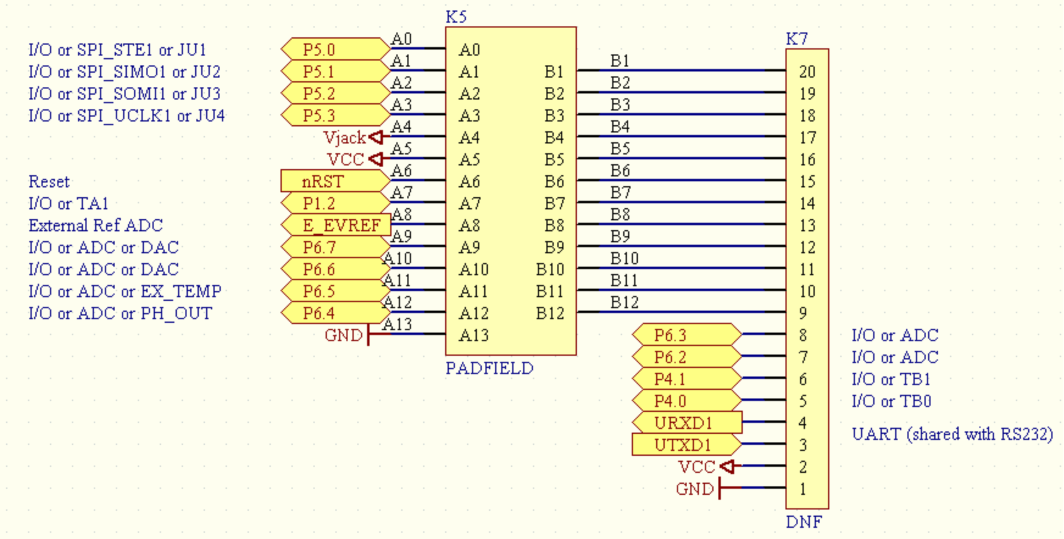
Figure 1 RH, T, and Dewpoint accuracies

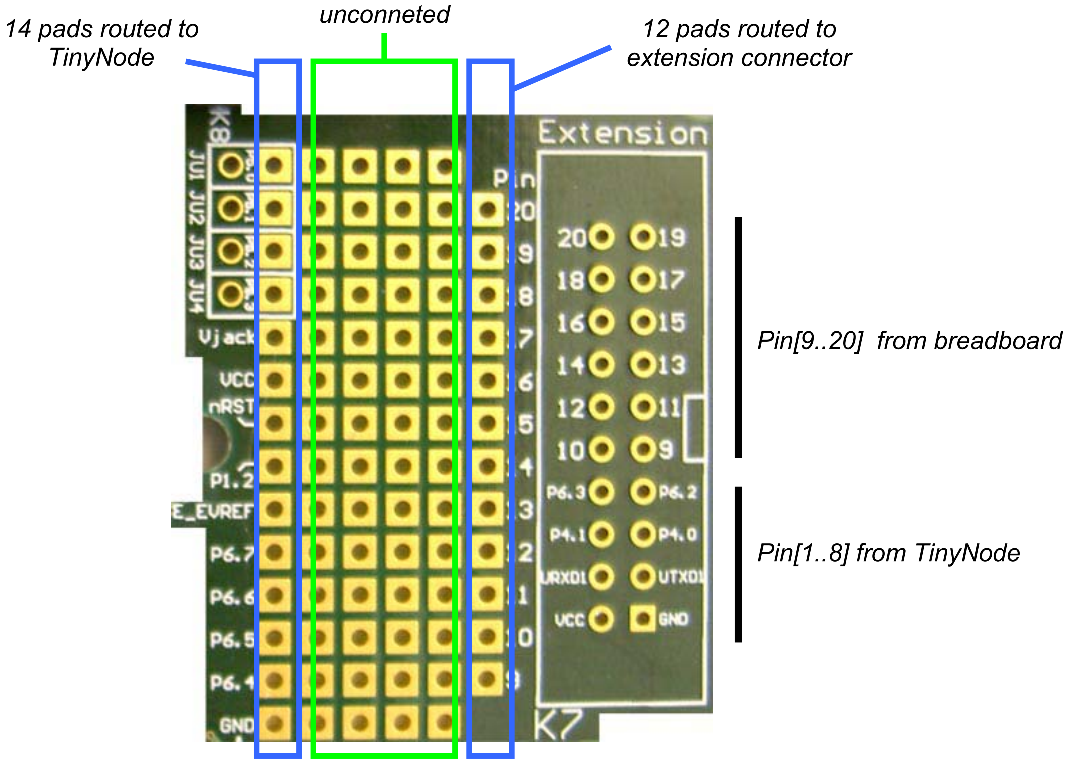
For more detailed information, please refer to the datasheet that is available at
http://www.sensirion.com

Breadboard and Custom Interfaces

The extension board features a breadboard that can be used to realize simple interfaces to custom sensors and/or other peripherals that may be controlled by the TinyNode module. It is a field of pads with standard 2.54mm pitch that has on one side 14 pads connected to different TinyNode I/O's and on the other side 12 pads connected to the 20-pin extension connector. Simple interface electronics can be soldered on the unconnected pads between those rows. The 8 remaining pins on the extension connector are "hardwired" to realize a simple interface without soldering any components. Depending on the number of pins used, a smaller connector can be soldered instead of the 20-pin connector.

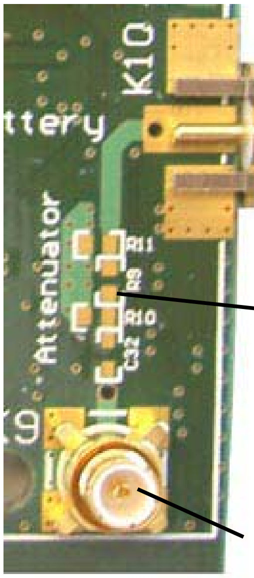
Since some of the pins are shared with other electronics (see diagram below), care must be taken in order to ensure that the additional electronics does not interfere.

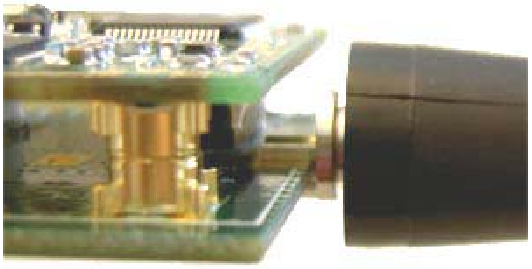




RF Extensions (optional)
The RF signal from the TinyNode can be routed to the extension board with a MMBX connector. On the extension board, a 50 Ohm PCB trace routs the signal to an edge mounted SMA connector. Both connectors are optional.

Between MMBX and SMA connector, the RF signal can either be bridged directly or attenuated by a simple resistive attenuator circuit in PI configuration formed by R9, R10 and R11. The table below shows different resistor values as a function of the desired attenuation. **If an attenuator is mounted on both sending and receiving board, the total attenuation will be the sum of the two attenuations!** The purpose of the attenuator is to reduce the link budget in a controlled manner for testing routing protocols.





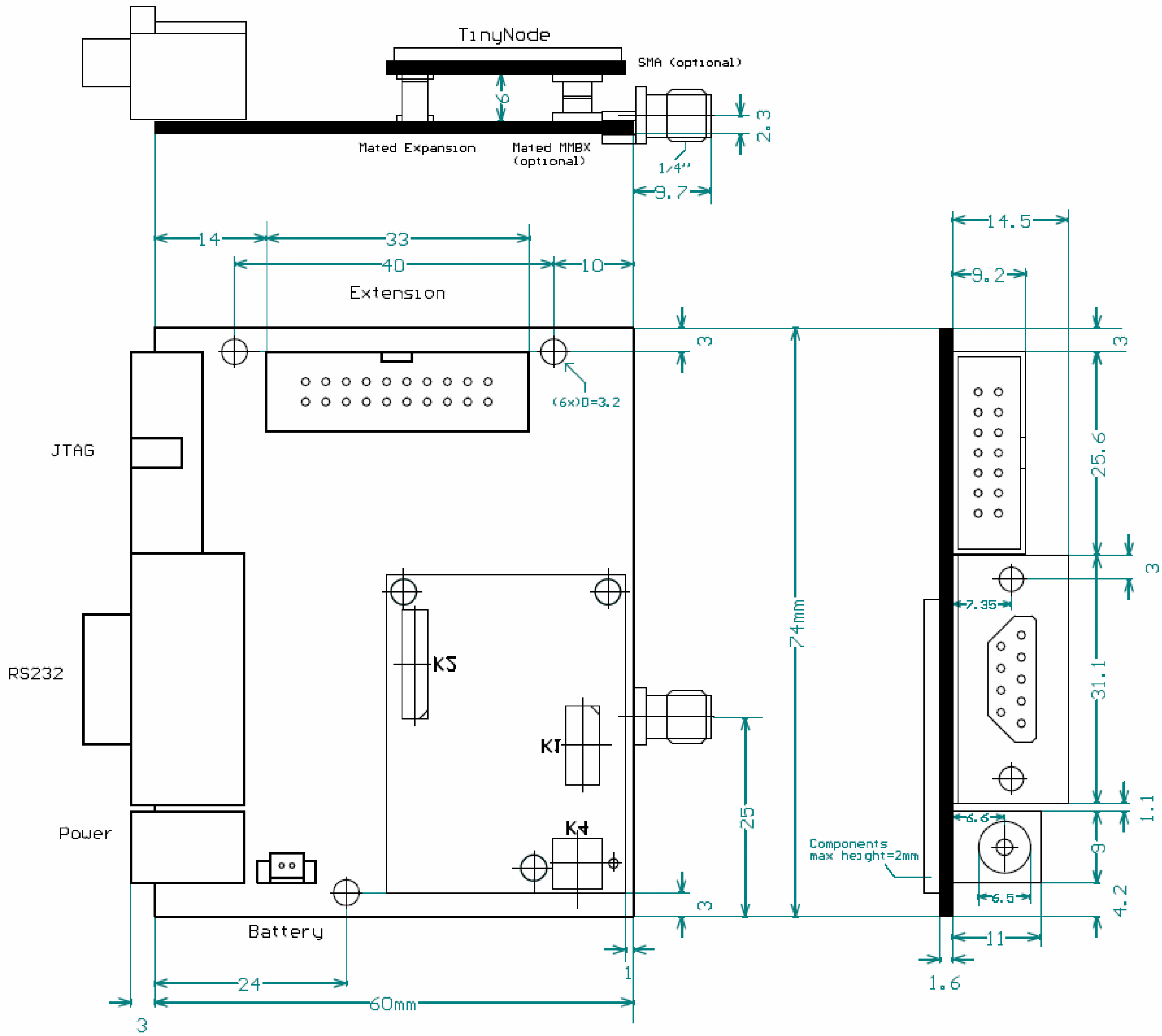
Attenuation [dB]	C32 [pF]	R10, R11 [Ohm]	R9 [Ohm]
0 (bypass)	33	not mounted	0
5	33	178.5	30.4
10	33	96.2	71.2
15	33	71.6	136.1
20	33	61.1	247.5
25	33	56	443.2
30	33	53.3	789.8
35	33	51.8	1405
40	33	51	2500

Capacitor C32: 5%, 0603 housing, COG Type
Resistors R9, R10 and R11: 1%, 0603 housing

The values mounted need to be as close as possible to the values above in order to keep 50 Ohms of impedance on both sides of the network.

The exact part numbers and suppliers for the connectors and a proposition for an antenna can be found in *Part Numbers and Suppliers*.

Mechanical Characteristics

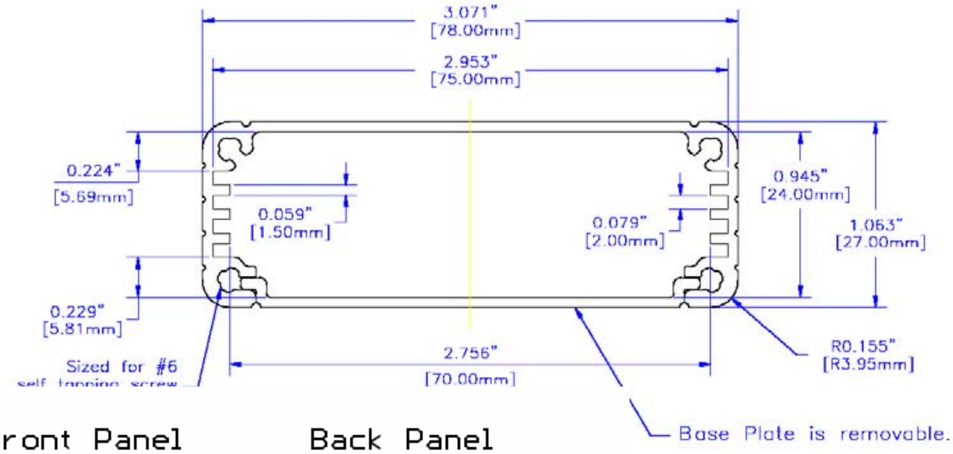


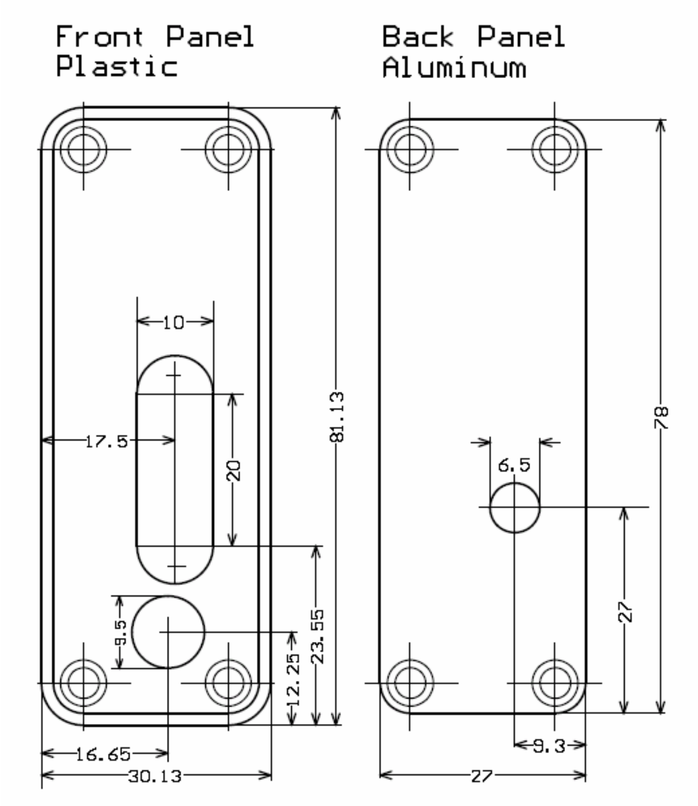
Housing Options
For indoor use, the extension board can be slid into a series 1455J housing from “Hammond Manufacturing”. The housing comes with two options for the front panel: a plastic version (1455J1201) and an aluminum version (1455J1202). We recommend using the plastic cover for the Front Panel (RS232, Power) and the Aluminum cover for the back panel (RF output). The aluminum panel will act as a ground plane for the antenna.

The standard length of the housing is 120mm, but custom length can be ordered. **The extension board will fit into a housing with 63mm body length.**

The exact part numbers and suppliers can be found in *Part Numbers and Suppliers*.

The 1455J housings are IP54 protected and for indoor use only. For outdoor use, a plastic housing with screwed cable glands and IP67 protection is recommended.





TinyNode Programming and Debugging
It is recommended to install the latest version of MSPGCC, a port of the GNU tool chain for the Texas Instruments MSP430 microcontrollers. MSPGCC includes an efficient C compiler for the MSP430 processor family, as well as tools and utilities for programming and debugging.

The software, source code and documentation can be downloaded at
http://mspgcc.sourceforge.net

Programming and debugging over JTAG:
MSP430 FETP programming adaptors can be bought online at
http://www.softbaugh.com/ProductPage.cfm?strPartNo=FETP

The cable supplied with the adaptor plugs directly into the JTAG connector of the extension board. The board needs to be powered via the Jack or a battery during programming or debugging.

Programming over RS232:
The RS232 serial port is connected to the Bootstrap Loader (BSL) of the MSP430 microcontroller. RTS and DTR are routed to TCK and nRST pin according to application note SLAA096B from Texas instruments. In order to avoid resetting the microcontroller when doing normal RS232 connections and communications, some reset logic has been added to the design.

For more information about the MSP430 Bootstrap Loader, you can consult application note SLAA096B or SLAA089A from Texas Instruments available at www.ti.com.

MSPGCC includes Bootstrap Loader software (msp430-bsl.exe) that can be used to program TinyNode over the RS232 port. Since it is a Python tool, you will also need to install Python 2.0 or newer on your machine. Python installations are available at www.python.org

Important: if you are using msp430-bsl.exe, you need to include the "--invert-reset" option in the command.

Example:
The command

```
C:\mspgcc\bin>msp430-bsl -epI --invert-reset file.ihex
```

…Clears all flash memory and programs the IntelHex file "file.ihex"

Please refer to the documentation available with the software for more details.

TinyNode Development Environment Installation

The goal of this chapter is to give you a quick guide of how to download and install necessary components to develop for TinyNode using TinyOS.

Automated installation (Windows)

The automatic installer let you easily deploy the development environment on your computer. It comes with all the necessary components and do not assume any prerequisite to be installed on your computer.

The installer enables you to select which component you would like to install. We recommend selecting all components.

After the installation procedure has completed, you can start the Cygwin shell by clicking on the TinyNode icon on you desktop. The last task is to build the java tools; at the shell prompt type:

```
cd $TOSROOT/tools/java; make; make
```

Then, move to the Shockfish directory and compile the TinyNode-specific java tools:

```
cd $TOSROOT/contrib/shockfish/tools/java; make
```

Please remember to keep your TinyOS sandbox up-to-date. To do so, please read the TinyOS CVS Repository section below.

Manual installation (Generic instructions Windows/Linux)

Cygwin (for Microsoft Windows only):
Cygwin is a Linux-like environment for Windows that is used as the development environment for TinyOS. It is recommended to install all the packages (the ones selected by default will not be sufficient), but you can also install them manually as needed.

Cygwin documentation: www.cygwin.com
Cygwin download and install: www.cygwin.com/setup.exe

Java:
PC tools that come with TinyOS will use Java. TinyOS tools are tested on Java 2 Platform, SE 1.4.2 (J2SE).

Java SDK download and install: http://java.sun.com/j2se/1.4.2/download.html

JavaComm:
This is an additional package for Java needed to access the serial port on your computer.

TinyOS CVS Repository:
SourceForge hosts the TinyOS CVS repository. The code in the /contrib./shockfish folder contains platform definitions and modules that are TinyNode specific.

TinyOS CVS installation guide: http://sourceforge.net/cvs/?group_id=28656
Browse CVS TinyOS: http://cvs.sourceforge.net/viewcvs.py/tinyos/
Browse CVS TinyOS, shockfish contributions:
http://cvs.sourceforge.net/viewcvs.py/tinyos/tinyos-1.x/contrib/shockfish/

Please keep your repository up-to-date and check for new updates regularly.

MSPGCC Toolchain:

This is the GCC toolchain for MSP430 microcontrollers. Includes the GNU C compiler (gcc), the assembler and linker (binutils), the debugger (gdb) and some other tools needed to make a development environment for the MSP430.

For download and install, we recommend using the build-mspgcc script in
http://cvs.sourceforge.net/viewcvs.py/tinyos/tinyos-1.x/tools/src/mspgcc

The script will download and install the latest version that will also support the relatively new MSP430F1611 processor.

If you prefer to do things manually, follow the instructions at
mspgcc homepage: http://mspgcc.sourceforge.net
mspgcc for Windows: http://sourceforge.net/project/showfiles.php?group_id=42303
mspgcc for Linux: http://mspgcc.sourceforge.net/manual/c1686.html#shopping-list

NesC:
NesC is the programming language used for TinyOS and it requires its own front-end compiler to be installed.

nescc homepage: http://nescc.sourceforge.net
nescc download: http://sourceforge.net/projects/nescc

NesC assumes the use of the Mica platform and tries to compile a new assembler for the Atmel avr processors, which is not needed if you work with TinyNodes. If you want to avoid this stage, you can type the following command into the shell prompt:

```
perl -i.orig -pe 's{\S+avr-as[^\s"]+}{}g if /^\s*ac_config_f/; $_="" 
if /avr-as/;' Makefile.in configure{,.in} tools/Make*
```

Environment:
In order to be able to start compiling and executing code, you need to set your environment variables correctly. As the variables slightly differ depending on your platform, a Windows and a Linux listing are provided below.

```
# TinyNode environment - Windows/Cygwin

# Java
export JDKROOT=/cygdrive/c/j2sdk1.4.2_05
export PATH="$JDKROOT/bin:$PATH"

# MSPGCC
export MSPGCCROOT=/cygdrive/c/mspgcc
export PATH="$MSPGCCROOT/bin:$PATH"

# TinyOS
export TOSROOT=$HOME/tinyos-1.x
export TOSDIR=$TOSROOT/tos
CLASSPATH="`$TOSROOT/tools/java/javapath`"
export CLASSPATH="`cygpath -w $TOSROOT/contrib/shockfish`;$CLASSPATH

# building TinyNode
export TOSMAKE_PATH="$TOSDIR/../contrib/shockfish/tools/make"
export MAKERULES=$TOSROOT/tools/make/Makerules
```

```
# TinyNode environment - Linux

# Java
export JDKROOT=/opt/j2sdk1.4.2_05
export PATH="$JDKROOT/bin:$PATH"

# MSPGCC
export MSPGCCROOT=/opt/mspgcc
export PATH="$MSPGCCROOT/bin:$PATH"

# TinyOS
export TOSROOT=$HOME/tinyos-1.x
export TOSDIR=$TOSROOT/tos
CLASSPATH="`$TOSROOT/tools/java/javapath`"
export CLASSPATH=$TOSROOT/contrib/shockfish:$CLASSPATH

# building TinyNode
export TOSMAKE_PATH="$TOSDIR/../contrib/shockfish/tools/make"
export MAKERULES=$TOSROOT/tools/make/Makerules
```

TinyOS Java Tools:
The TinyOS Java tools require the MIG utility provided by NesC to generate some source files for processing messages. Unfortunately, MIG assumes that avr-gcc has been installed on your system. To overcome this issue, you should first patch the toolchain:

```
cd ${TOSROOT}/..
wget http://www.shockfish.com/tinynode/patches/tinynode-mig.patch
patch -p0 < tinynode-mig.patch
```

You can now compile all the Java tools at once using the following command:

```
cd $TOSROOT/tools/java; make; make
```

Finally, compile the Shockfish-specific tools:

```
cd $TOSROOT/contrib/shockfish/tools/java; make
```

Part Numbers and Suppliers

Part Description	Manufacturer	Manufacturer Part Number	Supplier for CH	Supplier Part Number
Connectors TinyNode				
30pin extension connector on TinyNode	Molex	52465-3071	EME	52465-3071
…mates with	Molex	53364-3071	EME	53364-3071
Connectors Extension Board				
20pin expansion connector	Harting	0918-520-6324	Farnell	864-717
…mates with	Harting	0918-520-7803	Distrelec Farnell	12 28 36 302-2146
14pin JTAG connector	Harting	0918-514-6323	Farnell	864-778
…mates with	Harting	0918-514-7803	Distrelec Farnell	12 28 32 302-2122
Battery connector	Molex	53398-02	Farnell	889-374
…mates with	Molex	51021-02	Farnell Farnell	889-477 889-570
Power Jack connector	CUI Inc	PJ-102A	Digi-Key	CP-102A-ND
…mates with	CUI Inc	10.665	Distrelec	15 13 06
4x2 Jumper Array	Harwin	M20-9980405	Farnell	512-114
RF parts				
MMBX Connector for Tinynode	Huber & Suhner	82_MMBX-S50-0-1	Huber & Suhner	23001785
…mates with	Huber & Suhner	81_MMBX-S50-0-1	Huber & Suhner	23001782
SMA connector	Johnson	J502-ND	Digi-Key	J502-ND
RP-SMA connector[13]	Linx Technologies	CONREVSMA003.062	Digi-Key	CONREVSMA003.062
868MHz external antenna	Linx Technologies	ANT-868-CW-QW	Digi-Key	BH2AA-W-ND
Sensors				
Humidity Sensor	Sensirion	SHT11 or SHT15	Farnell	391-3065
Mechanical				
Spacers for 3.2mm hole, 6.4mm stacking	Richco	MSPM-4-01	Distrelec	34 04 96
Housing, plastic panel version, 120mm	Hammond	1455J1201	Farnell	427-2833
Housing, aluminum panel version, 120mm	Hammond	1455J1202	Farnell	427-2950
Housing, 63mm length	Hammond	1455J	Sibalco[14]	1455J, 63mm

[13] use this connector to add an external antenna from Linx Technologies
[14] minimum order quantity of 25pce apply

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